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PLANNING FOR THE FUTURE: A PROGRAM FOR PRESERVING AND INTERPRETING PALEONTOLOGY AND GEOLOGY IN JOSHUA TREE NATIONAL PARK

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Abstract—The Pinto Basin in Joshua Tree National Park is a recognized but largely unexplored site for Quaternary fossil remains. Sediments in this area have yielded abundant but fragmentary Pleistocene vertebrate fossils. Remains consist primarily of isolated dental and distal appendicular elements. Large and small horses and camels are most commonly represented, but specifically diagnostic fossils are rare. New investigations initiated by the San Bernardino County Museum, in cooperation with Joshua Tree National Park and the Joshua Tree National Park Association, focus on renewed recovery and preservation of vertebrate fossils as well as their geologic, stratigraphic and taphonomic contexts. More than 80 fossil localities have been identified since early 2003. Global Positioning System data were acquired for all new localities, for inclusion in the park's digital overlay. New discoveries include remains of *Anas* (duck), *Canis* (wolf-sized canid), *Mammuthus* (mammoth) and *Odocoileus* (deer), as well as probable records of Accipitridae (hawk or eagle), *Lepus* (jackrabbit), *Taxidea taxus* (badger) and *Capromeryx* (dwarf pronghorn), all new records for the fauna. The presence of *Mammuthus* demonstrates a Pleistocene age for the fauna, although previous suggestions of a late Pleistocene (Rancholabrean North American Land Mammal Age) date for the assemblage are not currently supported. Recommendations for future efforts to manage, conserve and interpret fossil resources adequately include the creation of a park-wide paleontology sensitivity overlay, cyclic field inspection, ongoing laboratory analysis, long-term curation in the park and implementation of interpretive programs in paleontology.

INTRODUCTION

Joshua Tree National Park (JOTR) is located in the southern Mojave and western Colorado Deserts, at the eastern extent of the Transverse Ranges (Fig. 1). Established in 1936 as Joshua Tree National Monument, then expanded and redesignated as a national park in 1994, JOTR is bordered by the communities of Joshua Tree and Twentynine Palms to the north, the Coxcomb Mountains to the east, the Cottonwood Mountains and the Eagle Mountains to the south and the San Andreas Fault Zone to the west. The eastern part of JOTR incorporates the Pinto Basin, a large desert drainage bordered and fed by the Pinto Mountains to the north, the Coxcomb Mountains to the east and the Eagle Mountains along the south (Scharf, 1935). Quaternary alluvial sediments, including fossiliferous alluvium, and Tertiary basalts in the region are discussed in this paper.

Fossils, particularly vertebrate fossils, have been among the least understood resources in JOTR. The disciplines of geology, biology and archaeology have all been well represented in studies conducted within the boundaries of JOTR and resources pertinent to those disciplines have been collected, analyzed and preserved. But fossils and the fossil record within the boundaries of JOTR have received comparatively little attention over the past several decades. Further, rather than considering the fossils as significant resources in their own right, these investigations were directed primarily at determining whether or not early humans may have coexisted with Pleistocene megafauna (Campbell and Campbell, 1935; Scharf, 1935).

Paleontological resources are critical for a comprehensive understanding and interpretation of the natural history of JOTR and the significance of its geological, biological and archaeological resources. The study of vertebrate fossils provides data helpful in elucidating the timing of geologic events. Biologically, fossils are important because present-day ecosystems are essentially points in an ecological and evolutionary continuum stretching back thousands and millions of years. Fossils provide a glimpse of ancient environments, providing a unique and irreplaceable perspective on living biological communities. Finally, given that past studies on the archaeology of JOTR suggested that human artifacts were demonstrably associated temporally as well as geographically with extinct Pleistocene megafauna in the Pinto Basin (Campbell and Campbell, 1935; Scharf, 1935), a more thorough study of the megafauna in question, its associated microfauna, and the times at which these animals lived and died would be highly significant.

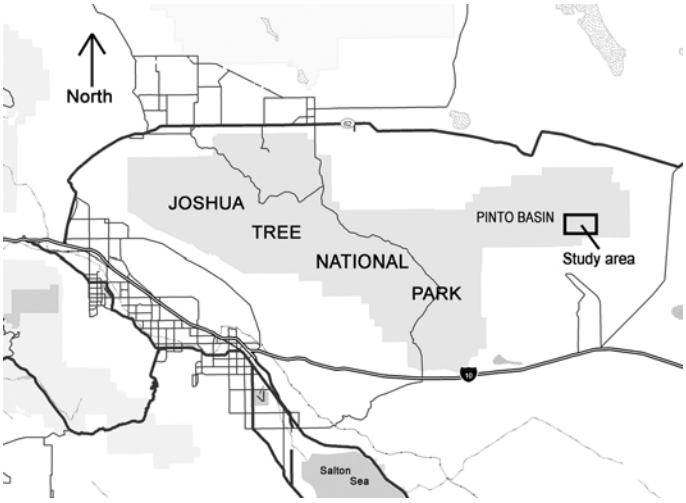

FIGURE 1. Map showing the boundaries of Joshua Tree National Park in southern California. The Pinto Basin and the study area are labeled.

Section Ia9A of the National Park Service (NPS) Strategic Plan for Fiscal Years (FY) 2001-2005 called for determining the condition of paleontological localities in national parks, requiring that 20% of known localities be in "good condition". As of early 2002, the status of paleontological investigations at JOTR was such that the park could not reach this goal. The full extent of fossil-bearing rock units within the boundaries of JOTR, particularly sediments present in the eastern Pinto Basin, had not been precisely determined. The nature of the fossil fauna from

this region was also poorly understood. Given the abundance and diversity of other large vertebrates elsewhere in the Mojave and Colorado Deserts such as mammoths, ground sloths, dire wolves, sabre-toothed cats, American lions, and bison – not to mention relatively large numbers of rabbits, rodents, squamates, birds, and fish – the fossil record of JOTR required more detailed exploration.

During a visit to the eastern Pinto Basin region in April 2001, NPS vertebrate paleontologist H. Gregory McDonald identified a distal metapodial of a small camel (*?Hemiauchenia*). During a subsequent January 2003 field excursion by San Bernardino County Museum (SBCM), paleontologists located, but did not collect, an additional four localities in a single afternoon. In February of 2003, the SBCM conducted a surface survey for paleontological resources conducted under Federal permit, as part of the JOTR "Geoscientists in the Park" program. More than two dozen previously unrecorded vertebrate fossil localities were found. Fossils recovered ranged from fragmentary to relatively complete, representing animals known from the fossil record of JOTR as well as previously unrecorded taxa.

Based upon this demonstrated paleontological potential, and in keeping with the recommendations of the NPS Strategic Plan for FY2001-2005, the SBCM implemented a detailed paleontological survey and analysis of paleontological resources from JOTR. The new study, conducted in cooperation with the Joshua Tree National Park Association, focused on renewed recovery and preservation of vertebrate fossils as well as their geologic and taphonomic context. The study also included an assessment of the condition of existing collections of fossils previously recovered from JOTR. This focus was proposed to advance the science of paleontology in JOTR as well as to enhance management practices and interpretive activities with the public.

BACKGROUND

The presence of vertebrate fossils in Pinto Basin was first documented by Campbell and Campbell (1935), who briefly mentioned the presence of mineralized vertebrate bones – mainly horse and camel. These authors noted that the fossils appeared to be derived from somewhat older fluvio-lacustrine sediments (named the Pinto Formation by Scharf (1935)) than the cultural materials, but nevertheless proposed that the artifacts and the vertebrate fossils might potentially be coincident temporally as well as geographically. However, paleontologist George T. Jefferson conducted a more focused study of the region in the late 1960s and early 1970s and proposed a depositional hiatus between the cultural deposits and the older bone-bearing fluvio-lacustrine sediments (Jefferson, 1973, 1986). This interpretation suggested that sedimentary surfaces were deflated by eolian processes, bringing Holocene artifacts into apparent association with Pleistocene fossils.

In the Pinto Wash region of the eastern Pinto Basin, Holocene lithic artifacts are found in association with fragmented, wind abraded and occasionally burned bone debris (Jefferson, 1973). These bones represent a relatively modern xeric fauna including *Gopherus* sp. cf. *G. agassizii* (desert tortoise), *Dipsosaurus dorsalis* (desert iguana), *Sauromalus obesus* (chuckwalla), Aves (birds), *Sylvilagus* sp. cf. *S. audubonii* (desert cottontail), *Lepus* sp. (jackrabbit), *Spermophilus* sp. (squirrel), *Neotoma* sp. (wood rat), *Canis* sp. cf. *C. latrans* (coyote), *Vulpes* sp. (fox), *Urocyon cinereoargenteus* (grey fox), *Lynx* sp. cf. *L. rufus* (bobcat) and *Ovis* sp. cf. *O. canadensis* (bighorn sheep) (Jefferson, 1991a). In contrast, the Pleistocene fauna from the Pinto Basin consists primarily of extinct large mammals, particularly equids and camels. These fossils are also fragmented and wind abraded, but are dark in color and frequently heavily permineralized; the latter condition clearly distinguishes many fossil bones from the more recent Holocene bones associated with cultural materials (Jefferson, 1991a).

Pleistocene fossils have been reported (Scharf, 1935; Jefferson, 1973, 1986, 1991a) in generally horizontal, well-bedded claystones, sandstones and siltstones exposed in low bluffs along Pinto Wash. In the northeastern Eagle Mountains, vesicular basalt layers of Tertiary (Miocene) age (Carter et al., 1987; Trent and Hazlett, 2002) overlie sediments of unknown age. Where in contact with the overlying Miocene flows, these sediments are red in color, indicating a baked zone (Jefferson, 1991a). Previously, the sediments in the northeastern Eagle Mountains were thought to be laterally correlative with the fossil-bearing basin-floor sediments (Jefferson, 1991a). Because the fossils reported from the Pinto Basin date to the Pleistocene Epoch (Jefferson, 1973, 1986, 1991a; this report), the older sediments beneath the Miocene basalts are neither part of, nor do they correlate with the Pinto Formation. As will be demonstrated herein, there are at least three sedimentary packages recognized from the study area: Pleistocene basin-floor fluvio-lacustrine sediments; fossil-bearing alluvial fan sediments perched above the Tertiary basalts; and older, fine- to medium-grained sediments interfingering with and underlying the basalts.

Taxa previously reported from the Pleistocene Pinto Formation include *Equus* sp. cf. *E. conversidens* (extinct small horse), *Equus* sp. (extinct large horse), *Camelops* sp. (extinct large llama-like camel), *Hemiauchenia* sp. (extinct North American llama) and *Ovis* sp. (sheep) (Jefferson, 1991a). As noted by Scott (1997), many of the records of *Equus conversidens* from the Mojave Desert are based upon insufficiently complete or diagnostic fossils, and so several of these records – including those from the Pinto Basin – are better referred to "*Equus* sp. (small)" with no species assignment. Extinct *Bison* has also been reported from the Pinto Basin (Jefferson, 1992), but the sole specimen is a large camelid, likely *Camelops* (Scott and Cox, 2002).

METHODS

The intent of the present study was twofold: to assist JOTR in assessing the paleontological potential of the park and to determine the status of fossils already recovered from the park. Both of these goals accorded with the recommendations of the NPS Strategic Plan for FY2001-2005 regarding fossil resources in national parks. With information provided by this study, management personnel at JOTR would be able to document, preserve and interpret paleontological resources and their geologic context more effectively. Evaluating the percentage of fossils or paleontological localities from JOTR in "good" condition would therefore be accomplished more readily. Further, the ability of JOTR personnel to consider which rock units in the park were likely to yield fossils would be improved. These data would be available in a GIS-based sensitivity overlay for the JOTR resource map.

The SBCM's initial field survey was conducted in February 2003; several subsequent field efforts were conducted in 2004, 2005 and 2006. New paleontological resource localities were assigned field numbers, described geologically, mapped and photodocumented in the field. Data for each locality were recorded through use of Global Positioning System (GPS) receivers. Taphonomically important positional data were also recorded, particularly the orientation of the fossil(s) relative to magnetic north.

Recovered specimens were cleaned, stabilized and hardened where necessary with Vinac thinned with acetone. The fossils were then housed in the collections of the Division of Geological Sciences, SBCM, stored in standard museum steel geology cabinets and trays. All data pertaining to the recovered fossils were entered into the SBCM's ARGUS© computer database for permanent storage, including locality information downloaded from GPS receivers into the SBCM's GIS database. Archival data slips generated from the ARGUS© database are associated with each specimen. The fossils and their data will be transferred to JOTR for permanent storage.

In addition to fossil documentation and recovery, SBCM paleontologists reconsidered the complex geologic relationships of rock units present in the eastern Pinto Basin region of JOTR. Future studies will be directed at establishing the correct relationship between fossil-bearing fluvio-lacustrine beds, alluvial fan deposits and basalt layers and interbedded sediments.

Intermittently during the study, previously collected fossil resources were located, reviewed and photodocumented, again as part of assisting JOTR in meeting the obligations of Section Ia9A of the NPS Strategic Plan for FY2001-2005. To accomplish this task, the SBCM conducted a search of repositories likely to have fossils originating from JOTR in their collections. Institutions consulted included: the Natural History Museum of Los Angeles County (LACM); the Riverside Municipal Museum (RMM); the San Diego Museum of Man (SDMM); the San Diego Natural History Museum (SDNHM); the Southwest Museum, Autry National Center (SWM); and the Museum of Paleontology, University of California, Berkeley (UCMP). These institutions were queried because of their demonstrated or potential involvement with paleontological resources from JOTR. Additionally, the Division of Anthropology at the SBCM was also queried to determine if any paleontological resources might be included in archaeological collections recovered from JOTR.

RESULTS

The renewed field survey confirmed the continued fossiliferous potential of the eastern Pinto Basin region of JOTR. Every field excursion conducted by the SBCM to date has resulted in the identification of additional localities and/or the recovery of additional fossils and most have added previously unrecorded taxa to the fauna.

SBCM paleontologists recovered a total of more than 200 discrete fossil specimens (>2000 total specimens, including fragments) from 48 *in situ* and 33 "float" resource localities. These fossils are presently housed in the collections of the Division of Geological Sciences, SBCM, where additional preparation and analyses are currently underway. Fossils represented were similar to previously published faunal lists for the Pinto Basin (Jefferson, 1973, 1986, 1991a), while four and possibly six previously unrecorded genera – *Anas*, *Canis*, cf. *Taxidea*, *Mammuthus*, *Odocoileus* and cf. *Capromeryx* – were also identified (see "Discussion").

The surveys to document regional geology had one important consequence: the identification of vertebrate fossils eroding out of alluvial fan deposits along the northern flanks of the Eagle Mountains. These discoveries documented for the first time the presence of significant fossil resources at JOTR from sediments other than the classic "Pinto Formation". These fossils are currently under study at the SBCM.

SBCM staff photodocumented catalogued fossils and their accompanying data from JOTR in the collections of the LACM. Fossils examined in the collections of the LACM were assigned to five genera: *Gopherus* (desert tortoise), *Equus* (horse), *Camelops* (large camel), "*Tanupolama*"(= *Hemiauchenia*) (llama) and *Bison* (bison). As discussed previously, the fossil assigned to *Bison* (LACM 3414/47255) has been reidentified, and is actually a camelid, likely *Camelops* (Scott and Cox, 2002). Fossils identified to the species "*Tanupolama stevensi*" (LACM(CIT) 208/47358 through 47362) are now referred to the species *Hemiauchenia macrocephala*, as the former species name has been subsumed into the latter (see Kurtén and Anderson, 1980). All of these fossils were derived from two localities: LACM (CIT) 208 and LACM 3414. Field photographs in the collections of the LACM will be helpful in future field investigations for relocating and further delineating these original collecting sites. These data have been provided to JOTR personnel.

SBCM paleontologists also documented vertebrate fossils in the Janish collection from JOTR, housed in the Division of Anthropology at the SBCM. Although these fossils consisted primarily of nondiagnostic large mammal bone fragments, some identifiable fossils of jackrabbit (*Lepus*) and small horse (*Equus*) were present. The bones of *Lepus* include tooth, jaw and limb elements; some of these remains have a relatively modern appearance and their status as fossils is questionable. The remains of small *Equus* include a partial right metatarsal (hind foot) and a left ectocuneiform (ankle bone). Both elements compare favorably in size with bones of present-day small horses, but are thoroughly mineralized and clearly fossil in nature. All of these fossils remain with artifacts from the Janish collection in the Division of Anthropology, SBCM.

Curatorial staff at the SWM reviewed site records from in and around JOTR to determine if paleontological resources might be present or if archaeological site records might contain mention of bones or teeth. Several records were identified from JOTR that mentioned the presence of bones. It is not known at the time of this writing whether these bones are modern, historic, prehistoric or fossil.

The present review did not locate any fossils from JOTR in the collections of the RMM, the SDMM, the SDNHM or the UCMP.

DISCUSSION

As with previous investigations, and as documented for much of the Mojave Desert (Jefferson, 1991b), camels and horses dominated the Pleistocene fauna from Pinto Basin. Despite a general lack of specific identity, many of the vertebrate fossils were diagnostic to the family or genus level. These identifications not only provided clues as to the nature of the animals represented, but also provided information pertinent to determining the geologic age of the assemblage. This last was an important point to establish. Earlier studies (Jefferson, 1992) suggesting the presence of *Bison* at Pinto Basin implied a later Pleistocene age (Rancholabrean NALMA) for the assemblage, but because the sole fossil assigned to *Bison* from the region is a large camelid, likely *Camelops* (Scott and Cox, 2002), this age assessment cannot be confirmed.

The field surveys in 2003 and 2004 did not yield indisputable index fossils. However, a tooth fragment (JOTR-789-27799) assigned to cf. *Mammuthus* was suggestive of a Pleistocene age, because this genus is exclusively Pleistocene in continental North America (Kurtén and Anderson, 1980; Lundelius et al., 1987; Bell et al., 2004). Additionally, the morphology of equid fossils recovered during these surveys, as well as of equid fossils collected previously and housed at the LACM, was strongly indicative of a Pleistocene age for the fossil assemblage. Equid fossils from several localities exhibited tall, straight cheek teeth, with mesiodistally long protocones on the upper teeth (Fig. 2), characteristic of Pleistocene and later horses. Late Tertiary North American horses such as *Dinohippus* have short, longitudinally curved cheek teeth that are distinctly different from those observed in the sample from the Pinto

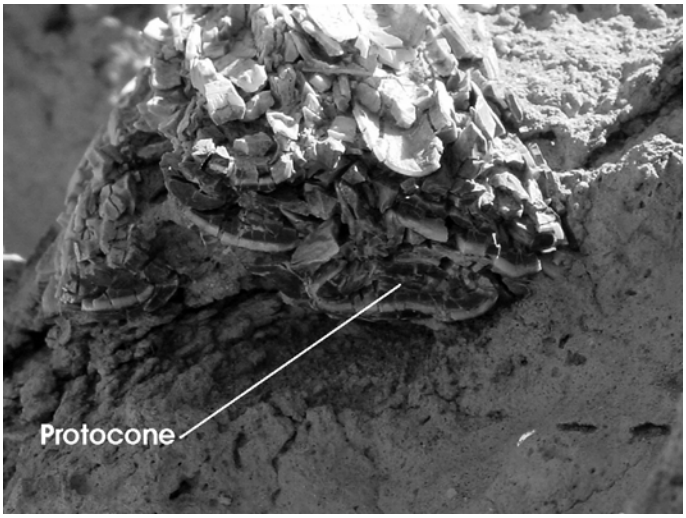

FIGURE 2.Upper left premolar of *Equus* (large horse; specimen JOTR-789-27824) exposed in the field, Joshua Tree National Park, oblique occlusal view. Anterior is to the left. The mesiodistal length of the protocone (labeled) suggests a Pleistocene age for this and associated fossils. Tertiary equids generally exhibit shorter, more rounded protocones. Mesiodistal length of protocone = 19.99 mm.

Basin. Latest Tertiary horses including *Equus (Plesippus) simplicidens* have taller cheek teeth than their forebears, but generally have small, rounded protocones; long protocones are more often a hallmark of Pleistocene horses. The presence of tall, longitudinally straight cheek teeth with mesiodistally long protocones in the horse fossils from the Pinto Basin is strongly suggestive of a Pleistocene age.

The 2005 field survey did result in the recovery of Pleistocene index fossils. Diagnostic molar teeth and associated tusk portions of *Mammuthus* (Fig. 3) were recovered from the "Pinto Formation"; tusk midshaft portions were also recovered from an additional two localities. These finds are highly significant for helping to confirm the Pleistocene age of the sediments.

Remains of extinct mammoths were not the only new records for

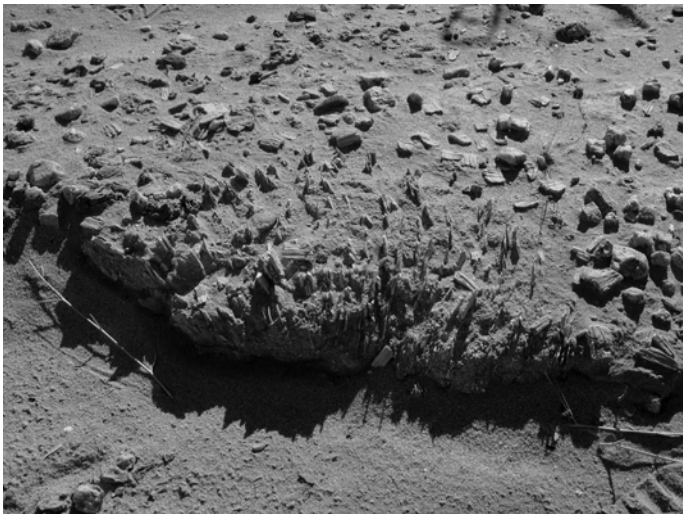

FIGURE 3. Molar tooth of *Mammuthus* (mammoth) eroding out of sediments of the "Pinto Formation", Joshua Tree National Park. The recovery of remains of *Mammuthus* from the "Pinto Formation" confirmed the Pleistocene age of these fluvio-lacustrine sediments. Approximate length of tooth (field estimate) = 36 cm.

the vertebrate fossil fauna. An eroded proximal tibiotarsus (JOTR-789-28371) from float locality SBCM 5.10.33 is assigned to cf. Accipitridae. This avian family encompasses the diurnal birds of prey, including hawks and eagles. Fossils of birds are generally rare in fossil assemblages, because bird bones are often thin, hollow and delicate and do not fossilize well as a consequence. The recovery of bird fossils from the Pinto Basin demonstrates the potential for recovering even very fragile bones from the fossil record of this region. This record and the find of remains of *Anas* mentioned later represent the first records of any bird fossils from the Pinto Basin.

A partial innominate (JOTR-789-27796) from locality SBCM 5.10.25 and a dentary with teeth (JOTR-789-28387) from locality SBCM 5.10.67, are assigned to cf. *Lepus*, the jackrabbit. Although a new record for the Pleistocene record from the Pinto Basin, *Lepus* is abundantly represented in the Holocene fauna from the site. The genus is also common in Pleistocene localities throughout southern California, including the Mojave and Colorado Deserts (Jefferson, 1991b).

A partial carnivoran incisor (JOTR-789-27812; Fig. 4) from locality SBCM 5.10.18, and a carnivoran scapula fragment (JOTR-789-28425) from locality SBCM 5.10.48 were also recovered. The incisor exhibits the dark mineralized color common to Pleistocene fossils from the Pinto Basin and so is interpreted to be a Pleistocene specimen. The tooth closely resembles like elements from large individuals of the genus *Canis*. The tooth is larger than comparable specimens of modern *Canis latrans* (coyote) in the collections of the SBCM and is similar in size to elements of modern wolf (*Canis lupus*). The specimen is not complete and it cannot be determined whether it represents *Canis lupus* or an extinct

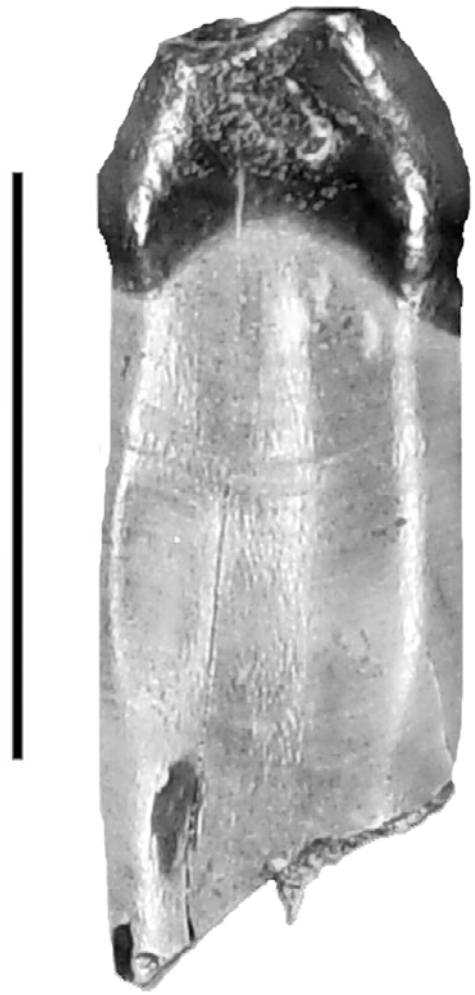

FIGURE 4. Incisor of *Canis* sp. (wolf size; specimen JOTR-789-27812) from Joshua Tree National Park, lateral view. This fossil is the first record of Pleistocene carnivorans from the Park. Scale = 1 cm.

wolf such as *Canis armbrusteri* or *Canis dirus*. For the purposes of this study, it is considered "*Canis* sp. (wolf size)". No carnivorans were previously recorded from the Pinto Basin and wolves are extremely rare from the fossil record of the Mojave Desert (Jefferson, 1991b), so this specimen is an important addition to the fossil record of both the local area and the broader geophysical region.

A proximal left radius (JOTR-789-27789) of a small carnivoran, from float locality SBCM 5.10.34, is assigned to cf. *Taxidea taxus* (badger). Badgers have not previously been reported from the Pleistocene fossil record of the Pinto Basin, although they are known from other Pleistocene localities in the Mojave and Colorado Deserts (Jefferson, 1991b). Carnivorans are generally rare in fossil mammalian assemblages, because such these animals are outnumbered by herbivores in biological communities. The recovery of the remains of both wolf-sized canid and badger from the fossil record of the Pinto Basin is therefore important in documenting the potential richness of the fauna.

A distal right humerus (JOTR-789-28383), also from float locality SBCM 5.10.40 is assigned to the genus *Odocoileus* (deer). This genus is not previously recorded from the fossil record of the Pinto Basin. Fossils of deer have been reported from elsewhere in the Mojave and Colorado Deserts, although these remains are usually less common than those of larger mammals such as horse, camel and mammoth (Jefferson, 1991b).

A left naviculocuboid (JOTR-789-28405) and a fragment of mesoectocuneiform (JOTR-789-28406) of a very small artiodactyl were

identified from locality SBCM 5.10.64. These elements resemble the dwarf pronghorn genus *Capromeryx* in size and morphology and are assigned to cf. *Capromeryx* for this reason. *Capromeryx* has not previously been reported from the Pinto Basin.

The fossils recovered during the field survey were generally found as isolated elements, an observation in agreement with previous studies (e.g., Jefferson, 1973, 1986). However, locality SBCM 5.10.21 yielded several bones and bone fragments from a single individual of juvenile small camel. This important finding suggests that other localities as yet unexposed and/or unrecognized in the eastern Pinto Basin region may also have potential to yield significant concentrations of fossils rather than isolates. Re-examination of this locality in early 2006 resulted in the recovery of multiple fossils of *Anas*, another new record for the vertebrate fauna, as well as a fragment of mammoth tooth.

The confirmation of a Pleistocene age for the vertebrate fauna necessitates a continuing re-evaluation of the relationship of the fossil-bearing "Pinto Formation" to the basalts and underlying sediments exposed in the Eagle Mountains to the south (Fig. 5). As stated previously, earlier studies (Scharf, 1935; Jefferson, 1971, 1991a) proposed that the "Pinto Formation" deposits "interdigitate with vesicular basalt flows" (Jefferson, 1991a), with baked sediments underlying the basalts. Because these basalts were originally interpreted to be Pleistocene in age (Hope, 1966), this relationship was not questioned. However, more recent studies (Carter et al., 1987) proposed an age of approximately 7.8 Ma (Late Miocene) for the Eagle Mountain basalts, substantially predating the Pleistocene (beginning approximately 1.8 Ma). The confirmation of a Pleistocene age for the vertebrate fossils from the "Pinto Formation" demonstrates that this unit is not laterally continuous with those sediments interfingering with, and underlying, the basalts.

Field examination by the SBCM in 2004 and 2005 distinguished

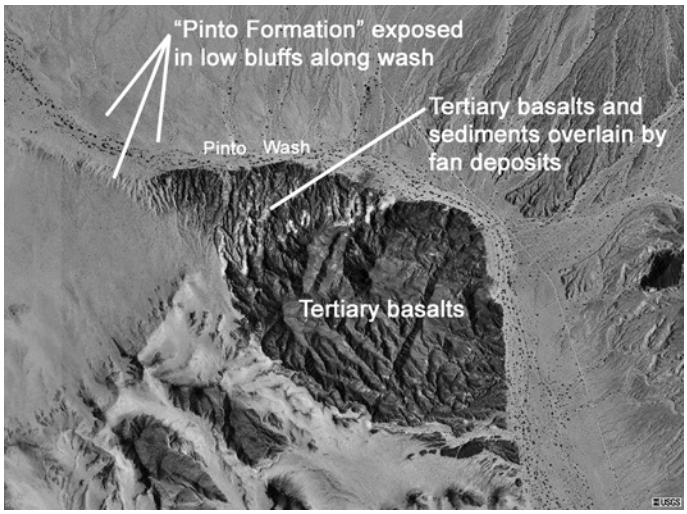

FIGURE 5. Aerial view of the eastern Pinto Basin and northeastern Eagle Mountains, Joshua Tree National Park. The sediments discussed in the text and their approximate spatial relationships are labeled. Base map courtesy United States Geological Survey.

at least three sedimentary units in the Pinto Basin and northeastern Eagle Mountains: 1) fluvio-lacustrine beds in the Pinto Basin floor; 2) uplifted and dissected fossil-bearing alluvial fan deposits, overlying Tertiary basalts, in the Eagle Mountains; and 3) uplifted sediments stratigraphically below the basalts in the Eagle Mountains (Fig. 6). The lateral relationship of the sediments above the basalts to the fluvio-lacustrine beds in the basin floor has yet to be resolved.

The stratigraphic position of the sediments below the Tertiary basalts demonstrates that they are a separate lithologic unit, predating the Pleistocene and having a different depositional history. Sampling to determine the fossil-bearing potential of these older sediments is planned

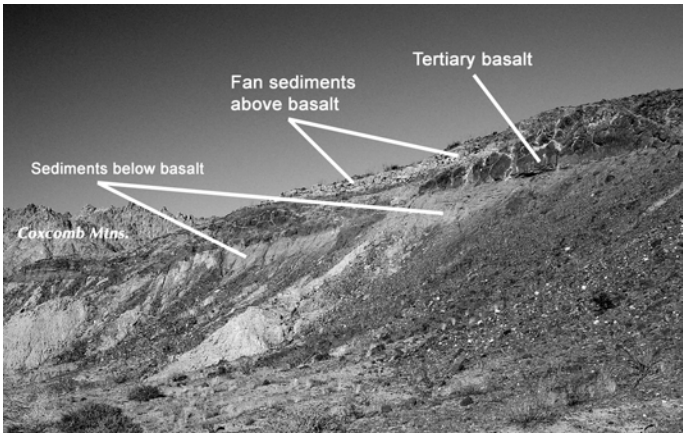

FIGURE 6. Tertiary basalts exposed in arroyos in the northeastern-most Eagle Mountains, Joshua Tree National Park. The presence of sediments perched atop the basalts, as well as older sediments below the flows, are clearly visible. View is north-northeast, with the Coxcomb Mountains in the distance.

for future field excursions. Further biostratigraphic and geologic mapping are warranted in this area to establish definitive corroboration of these field observations.

These findings are important for advancing scientific inquiries, in geology and paleontology – both regionally and throughout the Mojave and Colorado Deserts – as well as in regional archaeology and biology. These findings are also highly significant for helping JOTR effectively manage and accurately interpret its increasingly rich paleontological record. Management personnel will benefit from knowing where fossils occur and in what geologic context. The determinations advanced herein – that more sedimentary packages are present in the eastern Pinto Basin that have been previously recognized, that these sediments yield fossils from more areas that have been earlier explored and that these span a greater range of geologic ages that previously thought – enables resource managers to more effectively plan for the recovery and conservation of fossil remains.

Interpretation of natural resources is an important component of public outreach for any national park or monument. This interpretation requires accurate and up-to-date information on those resources in order to be truly effective, which is facilitated by both ongoing field studies and continuing review of available, carefully conserved natural history collections. The present study provides a wealth of data illustrating this point effectively. For example, the reidentification of remains assigned to *Bison* from the Pinto Basin as a large camelid (Scott and Cox, 2002), based upon a review of available collections, necessitated a reconsideration of the age of the fossils from the region. The field examinations demonstrating that the known fossil-bearing sediments from JOTR were not laterally continuous with sediments located stratigraphically below Tertiary basalts effectively rejected interpretations that the fossils were necessarily of Tertiary age, while the recovery of definitive remains of *Mammuthus* from the basin floor "Pinto Formation" confirmed a Pleistocene age for the fossils (although not necessarily a *late* Pleistocene age). All of these data are critical for correctly interpreting the geologic and paleontological history of JOTR and conveying those interpretations to the general public. Park personnel can now explain to interested park visitors that the known fossils from JOTR are of Pleistocene age, that the fossil record from the region is much richer than previously documented, that records of *Bison* previously on the books are in error, that mammoths were present in the region, that fossils are now known from more areas in the Pinto Basin that previously recognized and that more sedimentary packages remain to be explored for fossil remains. All of these findings will help JOTR interpretive personnel provide accurate information to park visitors, which in turn will foster a deeper apprecia-

tion of the natural history of JOTR as well as of the importance of both responsible collection and careful conservation of park resources.

CONCLUSIONS

Recent paleontological investigations in JOTR by the SBCM have focused on further documenting the nature and extent of resources and fossiliferous outcrops within the boundaries of the park, including both new field excursions and examination of existing collections. The field studies have confirmed the continued fossil-bearing potential of the "Pinto Formation" in the eastern Pinto Basin region of JOTR and have firmly established a Pleistocene age for the fossil assemblage with the identification of *Mammuthus*. These studies have also demonstrated that the full paleontological potential of this region remains to be tapped; short-term field surveys yielded taxa not only previously unrecognized from the fauna (*Anas*, cf. Accipitridae, cf. *Lepus*, *Canis*, cf. *Taxidea taxus*, *Mammuthus*, cf. *Capromeryx*), but also multiple elements from single individuals – a finding suggesting that more complete remains may be present in the subsurface. Additionally, previously unrecognized fossil-bearing dissected fan sediments along the southern border of the Pinto Basin were identified; these sediments, as well as the fluvio-lacustrine "Pinto Formation" require fuller exploration and mapping. The examinations of existing collections assessed and documented the condition of previously recovered fossil remains. Previously unrecognized vertebrate fossils were also identified in archaeological collections.

The data generated by these studies will enable JOTR personnel to better document, manage, conserve and interpret fossil resources present in the park. Future studies by the SBCM in JOTR will focus on more detailed geologic mapping throughout the park, on further delineation of the nature and extent of fossil-bearing sediments in and around the Pinto Basin, on recovery and conservation of fossils exposed in the park and on comparing these data in the broader framework of Pleistocene vertebrate faunas throughout the Mojave Desert.

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